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BIOLOGY.—*Biology and human trends.*[1] RAYMOND PEARL, The Johns Hopkins University.

I

To discuss adequately in a brief address the assigned subject "biology and the social consequences of its advances" is plainly a large order, and one beset with considerable difficulties. For on the one hand biology as a science is still largely in the descriptive and historical phase of its development, and sociology is even more so, with the consequence that an account of the significant achievements of these sciences cannot be expressed in the concise and rational short hand that is so useful in physics; and, on the other hand, to appraise the theoretical consequences of scientific discoveries implies a certain skill in the dangerous art of prophecy. Not having any noteworthy aptitude as a prophet I can only put before you, in all modesty, the views of one biologist about some of the more evident relations between certain well-established biological facts and principles and some of the more characteristic features of the collective behavior of mankind. While I cannot speak with officially sanctioned authority for more than one particular biologist it does seem absolutely certain that just in proportion as any of the sciences, including biology, succeed in their effort to establish sound general principles and laws, just in that proportion will their advances be inevitably reflected in collective human behavior. The thoughts and actions of all mankind were permanently and irreversibly altered from what they were before, after the *Origin of Species* had been published in 1859. A corresponding alteration, more or less significant as the case may be, occurs whenever a *real* discovery in science is made, or a sound generalization established.

II

In the great Symphony of Life there appear to be three, and only three, main, basic biological themes, out of which come all the pleasant or harsh, useful or harmful, simple or complex counter-melodies,

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harmonies, and dissonances of the business of living. These main basic themes are:

First: The urge to individual personal *survival* here and now. This appears to be an attribute of all living matter.

Second: The urge to *reproduction* which again appears to be a property of all that lives.

Third: *Variability*, once more common to all living matter, in both its genetic and somatic aspects, the one leading to the observed differences or variations between individual organisms, the other embodying the differences in the same individual at different times in its life.

Finally, it is to be remembered that it is impossible to discuss or even to imagine life or living things without taking into account the rest of the universe in which they exist. So then we must add to our material for discussion one more item that corresponds roughly to the fiddles, flutes, horns, printed music, desks, and other *impedimenta* not musical *per se* but without which a symphony would never reach the ears. This item is:

Fourth: The *environment* that conditions and in some degree determines all vital phenomena.

Let us now examine each of these four items in some detail.

The urge to survival[2] may fairly be regarded as the most fundamental attribute of living things and is therefore placed first in the list. It may be well to point out at the start that in its essence this urge to survival is rather completely and uncompromisingly selfish. To the best of its ability the individual organism so conducts its affairs as to continue living just as long as possible, regardless of what other organisms may do or think about it. When extinction threatens, every resource is brought to bear to fend it off. Basically this is what underlies the struggle for existence. Out of it, associated with it, and because of it come great ranges of biological phenomena that we have, for combined reasons of convenience and pedantry, departmentalized: such as food getting, metabolism and nutrition, cellular and humoral defense mechanisms furnishing immunity and resistance to disease, protective shelter seeking and building, natural selection, and in good part evolution itself.

[2] There are curious aspects to this universal urge to individual survival. One of them is the biological uselessness of much of it. It would be extremely difficult, if not impossible, to find any rational biological purpose served by the survival of the individual after it has reproduced itself. Yet in not a few organisms, including man, there is normally a considerable part of the life span lived after adequate reproduction has been accomplished. Living grandparents, great grandparents and celibate clergymen are among Nature's gaudier examples of Thorstein Veblen's "conspicuous waste" in the realm of pure biology.

As a matter of observed fact this survival urge is primal and deeply rooted. Whenever and wherever we see its fundamental selfishness apparently in abeyance or even much abated, and seemingly replaced by altruism or "mutual aid" as it has been called, we may be sure, I think, that one or the other of two things has happened. Either, as among the invertebrates (especially the social insects) and the lower vertebrates, the "mutual aid" is not individually motivated but is a mechanistic group consequence of caste differentiation and integration, with no more (and no less) of an altruistic element in it than there is in the cellular differentiation and integration in the embryonic development of the individual; or, as in man and to some extent among his nearest relatives, complex psychological elements have been added to the picture in the course of evolution, which may seem at times to overwhelm and obliterate the more primitive and deeply rooted biological urge. The most obvious of these added factors amounts really to a more enlightened self interest—that is to say a belief that for the present and until times get much worse it will be likely to conduce more effectively to individual survival to play along with and help one's neighbors in the crowd.

This statement is, from the necessity of brevity, much too bald and apparently dogmatic in its form, and wants more explanatory elucidation and development than we shall have time to give it. But I think it essentially conforms to at least a part of the reality. It is reasonable to suppose that the individual soldier ant is unaware of the fact that its activities and efforts are of benefit to the social group (the colony) to which it belongs. On the contrary it seems likely that when it fights it does so because it is its inherent and entailed nature so to do. In fighting it is expressing its own will-to-live or urge to survival, and in the only way of which it is capable. On the human side, in thinking of the personal motivation of altruistic behavior I am always reminded of a speech of Brotteaux in *Les Dieux ont Soif*, perhaps the greatest novel Antole France ever wrote. It is (I quote from Allinson's translation): "What I am doing now, the merit of which you exaggerate,—is not done for any love of you, for indeed, albeit you are a lovable man, . . . , I know you too little to love you. Nor yet do I act so for love of humanity; for I am not so simple as to think . . . that humanity has rights. . . . I do it out of that selfishness which inspires mankind to perform all their deeds of generosity and self-sacrifice, by making them recognize themselves in all who are unfortunate, by disposing them to commiserate their own calamities in the calamities of others and by inciting them to offer help to a mortal resembling them-

selves in nature and destiny, so that they think they are succouring themselves in succouring him."

Man's behavior, and particularly his social behavior, is motivated by so complex a set of physiological and psychological factors, appetites, emotions, and reasons, as to be extremely difficult to disentangle in a particular instance. But it may safely be said that whenever he curbs his primal urge to personal survival, he does it for secondary reasons superimposed upon his natural, protoplasmic will-to-live. Many of these reasons are, collectively, what we call social. They represent purposeful adaptations in what Wheeler has convincingly argued is the next emergent level above the individual organismal. In most human beings these secondary social adaptations of behavior are still somewhat incomplete and imperfect, as clearly appears in times of great stress or danger. And the extent to which the highest forms of human altruistic social adaptations have real and enduring survival value, has yet to be measured. It can be argued with some plausibility that why they give the appearance of having some survival value, or at least of not being positively harmful, is because they became even moderately widespread only during that recent portion of human history in which living has been relatively easy for all mankind. It has been relatively easy for two reasons: Low density of population, in general; and rapidly increasing knowledge of applied science with its accompanying industrial developments. In a world where getting a living was easy, altruistic social relations were correspondingly easy. Instances and localities of a real struggle for existence between individual men (other than during large caliber wars or in the processes incident to the assumption of the "white man's burden") have been rare in this world since the beginning of the nineteenth century. And few have ever seriously alleged that war is an altruistic enterprise; nor is it at all uncertain that the pleasures of "civilizing" backward peoples are, like those of condescension, singularly one-sided.

The urge to reproduce is second in power, if at all, only to that for survival. This basic attribute of living material, like the other, includes in its scope great ranges of academically labeled and pigeonholed biological phenomena—of which among the more important are perhaps population growth with its part in the struggle for existence and natural selection; and heredity with its concomitants of development and growth. For heredity is most clearly to be apprehended as an aspect of reproduction. Living things do not merely reproduce; they reproduce *themselves*. This fact makes it clear that,

philosophically viewed, the urge to reproduction is really a part—an extension if you like—of the primal urge to survival. If the individual cannot ensure his own indefinite earthly immortality he can and does try *his* very best to see that his stirp shall keep on living forever and ever. Naturally this self-reproductive process tends towards social as well as biological stability.

Genes are almost incredibly stable and resistant to alteration in the natural and usual circumstances of life. For something over fifteen years there has been going on in my laboratory a continuous experiment designed to test this point in a simple and direct way. Tonight I make the first public statement about it. This experiment has now included over 300 successive generations—perhaps the longest bit of controlled breeding ever carried out, with the results in each successive generation carefully observed and precisely recorded. Allowing 30 years as a round figure for the average duration of a human generation the time equivalent in human reproduction of this experiment would be of the order of 9000 years—considerably longer than the total span of man's even dimly recorded history. The objective of this experiment with *Drosophila* has been to see whether a simple Mendelian ratio involving but one character would or could be altered in the passage of time by such natural forces as selection, different systems of breeding (such, for example, as that called "grading up" by livestock breeders), and wide alterations of the environment nearly up to the limits of the organism's ability to go on living at all. The plan of the experiment is a simple one. It started by crossing a normal fruit fly (*Drosophila melanogaster*) possessing the normal wings characteristic of the species, with the pure mutant form *Vestigial*, so-called because the wings are reduced to non-functional vestiges. This wing characteristic is associated with a single gene. In the next generation all the flies produced by the pair with which we started had normal standard wings, normal being dominant to vestigial. These flies of the first cross-bred generation were then mated to pure vestigials (back-crossed to the recessive parent, in technical genetic language) to produce the second cross-bred generation. Of the offspring of these matings approximately one-half had normal wings, because they carried the original normal wing gene, and the other half had vestigial wings, all this being in accord with regular Mendelian expectation. The vestigial winged flies of this and all later generations were killed and thrown away as soon as they had emerged and been counted. The normal winged flies were again mated to pure vestigials to produce the next generation. And so on with undeviating regularity for

more than 300 generations. What the plan means in briefest terms is that since the rather stupendously long time (measured in generations) when the experiment began the only hereditary determiner (gene) for normal wings that has ever been in the system is the one that was contributed by the one single normal wild type fly with which we started. All the normal winged flies now appearing in the populations of the successive generations of the experiment have normal wings only because their *Urgrossvater* had them 300 generations ago, and for no other reason.

The net result of the experiment has been to show that the gene involved has preserved its initial characteristics unaltered. So also has the cellular mechanism for the shuffling and sorting of the genes in each generation. The approximately 50-50 ratio of normal winged to vestigial winged flies appears generation after generation with somewhat wearisome regularity. The demonstration of the inherent stability of the genic mechanism of heredity that this experiment has given is extremely impressive.

Analogous phenomena of organic stability are observed in nature. There are considerable numbers of firmly established instances of organisms living today that are *specifically* identical with their progenitors in earlier geological eras. Among the Foraminifera one species (*Lagena sulcata*) has persisted unchanged from Silurian times down to the present; one species (*Globigerina bulloides*) from the Devonian to the present; two species from the Carboniferous; two from the Permian; four from the Triassic; seven from the Jurassic; and fifteen from the Cretaceous. The significance of these cases cannot be overemphasized. When it is comprehended that organisms now living have not changed by a perceptible amount from what they were millions upon millions of years ago in paleozoic times in those *minutiae* of structure upon which systematists base their specific distinctions and descriptions, the conservatism and stability of nature begins to be realized.

In human biology the conservative and stable element of true biological heredity is supplemented and reinforced by what has been variously called "social heredity," or tradition, or the mores of the group to which the individual and his stirp belong. This is, of course, not inheritance at all in a proper biological sense. It is rather an environmental matter at bottom. A born Englishman transported to America as a child may, and in fact usually does, come as a man to think and act like an American. But to make him do this if he lives his whole life in England among the people of his kind would be vir-

tually impossible. And it is a matter of statistical fact that vastly more human beings live out their lives not far from where they were born and among their kind of people, than migrate or are transplanted into realms of other traditions and mores. In consequence "social inheritance" or tradition plays an enormous, but usually underestimated part in determining the individual and collective behavior of human beings. Its effects have not infrequently been confused with those of true biological heredity. Masses of data have been collected to show that near relatives, particularly fathers and sons, frequently follow the same professions or callings. It is often quite erroneously concluded that such facts prove a biological inheritance of talent or ability, either in general, or for a particular calling, or both. Such data are inherently incapable of proving any such a conclusion. The observations can be much more simply and satisfactorily accounted for in the main by the operation of the purely environmental factors of familiar contact from childhood, training, easy opportunity of entrance, and the social pressure of tradition; in short by "social" not biological inheritance.

Our third unique and universal biological principle, variability, has two aspects, as has already been pointed out. No two living organisms are exactly like each other in all particulars, and no single organism is precisely the same at any two moments in its lifetime. The first of these aspects is the only one that is conventionally called variability. It is mainly caused by the combined interaction of genetic shufflings and recombinations and the environment. The second aspect of organic variability is usually and conveniently called adaptability. It is an odd and remarkable phenomenon. The unique thing is not that organisms are more or less fitted or adapted to the circumstances in which they find themselves. Inanimate objects of various sorts, and particularly that category of them that we call machines are this. It is true that the adaptations of organisms and machines are brought about in different ways. But the fact of adaptation is present, and in principle identical, in both. We are, however, not concerned here with adaptation, but with self-started and self-controlled *adaptability*, which organisms have and machines do not. Organisms incessantly change and alter themselves to meet the fleeting changes in their circumstances. No living organism ever stays put. When it does it is dead, and in dying has passed into a wholly different category of matter.

The process goes even deeper than change and adaptability in behavior. The very material substance itself that makes up the living

organism is constantly changing. What then does "personal identity" connote? What we are pleased to call the same identical man at the age of 70 years is composed of extremely little if any of the same material substance that made him up when he was 20 years old. Probably there is not a single molecule in him at 70 that was there at 20. In the intervening years the only thing about him that has survived is his *pattern*, a sort of transcendental or spiritual wraith through which has flowed a steady stream of matter and energy. There is a profound truth embodied in Cuvier's old comparison of a living organism to a whirlpool. It is the pattern that is the essence of the business. It alone endures. And it is constantly altering and adapting itself to changing circumstances. Especially is this true and important of the psychological panel of the total pattern of the human organism. It is this aspect of adaptability, the capacity of organisms for change ending only with death, that seems to be more important in its social consequences than its teleological aspect, if indeed we are prepared to admit the reality of the latter at all, as some are not.

We may conclude this hasty survey of basic principles with a word or two about the environment. The *effective* environment of any particular living organism is determined by the pattern of that organism, just as truly as the pattern of the organism is in part at least determined by the environment. For a particular man, and for a group of similar men, but not for any mouse, the relative honesty of his banker and the urbanity of his dean are highly important elements in the effective environment. And what makes them so is not the bankishness of the banker nor the deanishness of the dean, but the pattern of the particular man of whom we are speaking—a pattern not shared by the mouse. In short the relation between organism and environment is everywhere and always mutually reciprocal and as man is the most complicated and manifoldly diverse in his capabilities of all organisms, so also is his effective environment the most complicated.

More extensively and more effectively than any other organism he *makes his own environment*. He is constantly altering it in the hope of making it better. But such is the interplay of the contradictory biological elements in his nature that he dislikes and resists any alteration of his environment by anyone else than himself or the group of people similar to himself to which he belongs. The social and political consequences of these opposing attitudes are far-reaching and encompass within their range the greater part of our communal troubles in this imperfect world.

The full implications of the reciprocally determinative influences of

organism and environment seem to me to have been generally somewhat less than adequately valued in the last century's development of biological thought, and certainly an extremely inadequate amount of first-rate research has been put upon the matter. This is partly an obvious consequence of the trend given to biological philosophy by Darwin, Galton, Weismann and Mendel, with their emphasis upon the entailed or endowed element in the whole biological picture. In human biology particularly the rôle played by heredity has come to take on many of the aspects of religious dogma. Indeed it has been urged that eugenics should be overtly espoused and developed as a religion. And all this has been going on in a world where consciously planned and directed alterations of environmental conditions have had far-reaching and profound biological effects upon whole populations, not alone in the field of public health but in many others. Every geneticist knows that the final expression in the individual of each hereditary determiner is conditioned by the environmental circumstances under which its development is undergone. Yet very little has been done in the way of attempting to analyze thoroughly and penetratingly the biological effects of environmental conditions upon human beings.

In truth science, perhaps in common with all other modes of human thought, has a seemingly ineradicable tendency to crystallize its temporarily successful philosophies into dogma, and having accomplished the crystallization proceeds to the scourging of whatever skeptics and heretics may appear. Public health workers sometimes display a religious attitude toward their achievements as intense as the crusading zeal of the eugenists for their dogmas. Only a few hardy souls throughout history and at the present time seem able to realize for longer than brief periods that new knowledge is more often than in any other way engendered out of skepticism by hard work, and that religious attitudes and modes of thought for however noble a purpose enlisted not only have nothing whatsoever to do with science, but are the most effective hindrances to getting new knowledge yet heard of.

III

Let us now turn to the examination of some of the more conspicuous and far-reaching social consequences of the basic biological principles we have briefly reviewed. The three most obvious and important ones are, I think, that:

1. Man is enjoying better health and individually surviving longer

than ever before, likes it, and intends to go farther along the same road.

2. He is vaguely conscious of being more crowded than ever before, and finds the various consequences of this crowding increasingly unpleasant, but chiefly because it threatens that enhanced survival that is always his first and deepest biological concern.

3. Therefore he is groping about to find ways to alleviate the progressive overcrowding and preserve the health and survival gains he has made; trying a great variety of experiments, some of which are sensible, others highly dubious, and a few completely idiotic.

For the sake of clarity these three statements need a little expansion. The urge to survival is the ultimate biological motivating factor that has transferred the maintenance and improvement of health from an individual to a social concern. The gains in this field have been enormous. How enormous perhaps only a statistician can appreciate. This is not the place, nor is there any need, to go into the question of how they have been achieved. But the interesting thing about the case, broadly viewed, is that without the abatement by a single bit of that basic individual selfishness in which the biological urge for survival is rooted, it has been perceived that this urge can be most effectively served so far as health is concerned by making a social matter of a great part of it. Assuring a pure water supply and innocuously disposing of the waste matters of living are things that the individual simply cannot do well. Society can. And the social progression of the urge to survival in the field of health is by no means at an end yet. In two directions we may confidently look forward to great further changes and advances in the rather immediate future. In the first place, whether we or the physicians like it or not, it seems clear that the maintenance and improvement of *individual* health is going to become more and more completely a social matter. The basic reasons are two-fold, partly because of the continued normal evolutionary further growth of the same ideas and considerations that have brought us to where we are now regarding public health; partly because of economic and political considerations. The number of persons who at the present time get inadequate medical care because they cannot individually afford to pay for adequate (and lacking it endanger other peoples' health) is so large that as a group they are already in a position politically to demand and get necessary medical service, and may reasonably be counted upon shortly to do so. In the second place it seems reasonable to suppose that advances in medical science are going to continue. The last seventy-five years —an exces-

sively small fraction of mankind's earthly history—have witnessed more progress in knowledge of disease and its effective treatment and prevention, than was made in all the time that went before. And objectively viewed the rate of advance in medical discovery seems plainly to be accelerating rather than slowing.

Turning now to the consideration of the social consequences of the urge to reproduce it is immediately to be noted that the growing consciousness of overcrowding—too many people in the world for comfort—is not the resultant of such simple matters as lack of space in which to build dwellings or to move about, or of inability to produce food enough to satisfy the collective hunger. It is true that the total number of living human beings on the globe at this moment is probably something closely approaching two billion. But the gross land area of the globe is about 35 billion acres, so that on an equal parcelling each individual man, woman and child would have over 17 acres. If the total population of the earth were to be forcibly put upon the smallest of the continents—Australia—there would still be, on an equal division, well over an acre for each individual. Similarly relative to food whatever trouble there is relates to distribution rather than production. Such famines as occur now happen not because there is not enough food produced to feed everyone, but because the complex economic mechanism of getting it to the hungry works imperfectly.

The social consequences of population growth present a much more subtle and complicated problem than mere space or food. The suggestion just made that the total land area of the globe might be equally divided per head of population is an obviously fantastic one, with only a sterile arithmetic meaning. Not all the land is equally useful for sustaining human life either directly or indirectly. Some of it is of no use whatever. And this brings us to the crux of the population problem, which is that each unit of the population must somehow or other *get its living*. All other forms of life except man get their living by one or the other or a combination of two direct ways. These are (1) by preying upon other living things, plant or animal; or (2) directly converting inorganic materials into living substance. Man today gets his living by indirect processes conveniently labelled economic. He is in the main employed in doing things that he can trade with somebody else for the biological requisites for living. The population of the world has now become so large, and the discoveries and applications of science have made the producing of the things that can be traded so much easier than it used to be, that great numbers of people all over the world find themselves unable to get a living by this process

that was formerly so relatively simple. The rapid development of the industrial type of civilization in the nineteenth century made the gloomy prophecies of Malthus at its beginning look silly. The population grew at a tremendous pace when he thought its growth would be checked by want and misery. And people were having, by and large, a grand time while their number was increasing; because they were experiencing the enormous improvements in the physical comforts of living that came with the advance and applications of science. But these very factors, plus the enhanced survival rate coincident with the development of public health, caused the ugly spectre of unemployment to rear itself higher and higher until it has now become the most serious problem that humanity faces.

It is to be noted at this point that in modern civilization, as a normal consequence of the relation of individual man's biology to his age, approximately 50 per cent of all human beings have to earn the livings not only of themselves but also the major part of that of the other 50 per cent. Man develops slowly. Children are incapable of earning their own livings before they are about 15 years old, and have passed approximately a sixth of their total life span, and between a third and a fourth of their average life duration. At the other end of life, for the great majority of human beings over 50 years of age their living must come in whole or in considerable part either from the efforts of the active workers between 15 and 50, or from what they themselves were able to save while they were in their productively efficient ages. In practically all countries the sum of the numbers of persons under 15 and of those over 50, is almost exactly equal to the number of those between 15 and 50 years of age. But over and above this burden, that may fairly be called a normal biological one, the world's workers are now called upon to support the unemployed. A considerable part of the unemployed are so because they are unemployable—not sufficiently fit and able in a biological sense to make an honest living in a world organized as this one is. These unfit organisms are kept alive by the rest of society for no realistically demonstrable reason other than that they were once born, and by being born somehow placed upon the rest of mankind what has gradually come to be regarded as a permanently binding obligation to see that they do not die. The remainder of the unemployed are so because there are too many fit, able and employable people in the world to do the necessary world's work, the aggregate amount of which has been, is being, and will continue to be steadily reduced by discoveries and improvements in the sciences and arts.

Mankind is trying in several ways to meet this situation. The first and in the long run perhaps the most important way is by reducing its reproductive rate through the practice of contraception—birth control. It has been seriously alleged and with at least some justification, that even the admittedly imperfect techniques of contraception as they are now known constitute the most important biological discovery ever made. While historians of the subject attempt to show that the practice of contraception is almost if not quite as ancient as man's recorded history, actually the birth rates of large population aggregates did not begin to be sensibly affected by it until roughly the last quarter of the nineteenth century; that is to say since the beginning of the rapid development of the highly organized, integrated and urbanized industrial type of civilization. At the present time the effects of contraception on the birth rate are plainly apparent over large and leading parts of the world's population, and are growing at a rather rapid rate.

The practice of birth control is a thoroughly sound, sensible, and in the long run effective method of meeting the problem consequent upon the biological urge to reproduction operating in a universe of definitely limited size. The only objection of importance that can be urged against it is that it has led to an unfavorable differential fertility. The socially and economically more fortunate classes of mankind have practised contraception more regularly, frequently, and effectively than the less fortunate social and economic classes, with consequently reduced reproductive rates. It is contended that this has brought about a steady deterioration and degeneration of man as a species, and will continue to do so until all progress is stopped. After prolonged study of the matter it is my opinion that the alleged detrimental consequences of this class differential fertility upon the aggregate biological and social fitness and worth of mankind, while doubtless present in some degree, have probably been greatly exaggerated in the reformer's zeal to make his case. This is not the place, nor is there time, to state and document all the reasons that have led me to this view. But there are certain considerations that must be mentioned because they have been so consistently overlooked or suppressed. The first is the tacit assumption that lies at the very root of the argument. This assumption is that generally speaking and with negligible exceptions the more fortunate social and economic classes are in that position because they are composed of not only mentally, morally, and physically, but also genetically superior people. But it may be alleged with at least equal truth that these very people who

are regarded as mentally, morally, and physically superior are that way in no small part only because they and their forebears have been fortunate socially and economically. The analogy often drawn between human breeding and live stock breeding is in part specious and misleading. In animal breeding it has been learned that the only reliable measure of genetic superiority is the progeny test—the test of quality of the offspring actually produced. Breeding in the light of this test may, and often does, lead to the rapid, sure, and permanent improvement of a strain of livestock. But when the results of *human* breeding are interpreted in the light of the clear principles of the progeny test the eugenic case does not fare so well. In absolute numbers the vast majority of the most superior people in the world's history have in fact been produced by mediocre or inferior forebears; and furthermore the admittedly most superior folk have in the main been singularly unfortunate in their progeny, again in absolute numbers. No one would question the desirability of the free multiplication of people who are really superior genetically. But in human society as it exists under present conditions of civilization many a gaudy and imposing phenotype masks a very mediocre or worse genotype, and *vice-versa*. And most eugenic selection of human beings is, and in the nature of the case must be, based solely upon phenotypic manifestations.

Naturally it is to be understood that what has been said does not refer to the problem of the really biologically defective and degenerate members of society. There the eugenic position is sound and admirable in principle. The breeding of such people must be stopped; and by compulsory measures. Voluntary birth control will not help appreciably to the solution of the problem, for the persons concerned are not of a sort to make effective use of contraception. If all the contraceptive techniques in the world were made fully available to them they would still go on breeding. There are but three ways, all somewhat imperfect, of dealing with them; they must be segregated, or sterilized, or denied any aid in the struggle for existence and thus allowed and encouraged to perish because too unfit biologically to make livings for themselves with their own unaided resources.

One final point and I shall have done with this phase of our subject. It is a curious fact that at every stage of man's history from at least the time of Plato, and indeed of Theognis of Megara a century before that, there have been those who have been just as certain as some present day eugenists are, and just as deeply grieved, that mankind was going rapidly to the dogs because the right kind of people

were not breeding enough and the wrong kind of people were breeding too much. Perhaps men are nearer the dogs now than they were in the Alexandrian age; but I venture to doubt it. The evidence seems to me overwhelming that mankind is, on an average, mentally, morally, and physically much superior today to what it was when Socrates was abated as a public nuisance.

So much for birth control and the eugenic objections to its alleged consequences. We turn now to the most ineffective, cruel, and altogether foolish large scale method by which society tries periodically to ameliorate the consequences of the biological urge to reproduction, namely war. If this characterization is reasonably in accord with reality why do we go on having wars? The reason has been stated with precision by a clear thinking human biologist, C. C. Walker, in the following words:

"The natural striving after security by one people, that is to say its natural endeavors to exist, must affect the security of other peoples. Because when a people endeavors to ensure its existence, by reason of its automatic reactions to the problems connected with food-supply, security, and social stability, its endeavors will conflict with the strivings of other peoples who are also subject to the same environmental problems. Each people is only trying to exist. When a people considers that its existence is threatened by a particular environment, . . . to such an extent that no adaptation to the environment will suffice, it is forced to attempt to alter that environment. But other people may consider that any alteration of that environment affects its own existence. The result is war."

Is there any reason to suppose that this biologically natural process, with its characteristic of almost rhythmic recurrence, will ever come to an end? It seems to me there can be such a hope only in the long —very, very long—run. And the only reason I can see for even this deferred hope is the already great and rapidly increasing ease, speed, and cheapness of transportation and communication between all parts of the world. The slow but steady and sure biological effect of easy getting about will inevitably be more and more interbreeding, with a gradual lessening of the racial and national differences between human beings. In the far-off end all mankind will presumably be a rather uniform lot; all looking, thinking, and acting pretty much the same way, like sheep. National or racial isolation has even now become extremely difficult to maintain; indeed in a quite literal sense the attempt to maintain such isolations already threatens group survival in not a few instances. In the long run they cannot and will

not be maintained. Just in proportion as they diminish so will the frequency of wars diminish. But the diminution seems likely to be at a fearfully slow rate; it will be a long time yet before the *last* war is fought. And a low cynic might suggest that even war, horrid and stupid as it is, would be preferable to that deadly uniformity among men towards which we are slowly but surely breeding our way.

Society here and abroad is just now experimenting with a whole series of internal readjustments that are being forcibly imposed upon temporarily dazed but always adaptable populations, in the hope that out of them will come a real and permanent solution of the problem that man's urge to reproduction has saddled upon us. All of these experiments appear to fall into a few simple categories when realistically examined. They all stem from and put into practice one or the other of two ideas, neither of which finds unqualified support in the science of biology. The first of these ideas is that it is best to let one individual in a group run the group's affairs; permanently, absolutely and without interference, on the philosophy that averaged opinion and averaged action are as stupid, inefficient and unreal as an averaged egg is innutritious and unreal. The other and opposite idea is that it is best to have the whole group run the business as a whole, allowing no individual any powers except as a merely mechanical executor of the group's will, on the philosophy that no individual is really superior to another and that therefore in averaged opinion and action wisdom alone resides. In their practical implementation, performance, and effects both ideas turn out to be singularly alike. Both alike scorn the intermediate idea of true democracy. And finally both attempt to solve the problem that is pestering the world by a simple procedure universally regarded as criminal when practiced by an individual. It is that the more abundant life is to be assured to a too abundant people by stealing goods from the prudent and efficient, and then giving them to the imprudent and inefficient. Since there are always a great many more of the latter kind of people than of the former this turns out temporarily to be the most effective political device ever heard of. Whether it will prove to be so permanently is less certain. It has been pointed out earlier in this paper that adaptable as man is there are nevertheless elements of conservative stability in his biological make-up whose roots go back to the very beginning of his evolution. And in that perfect state of society envisaged by our major prophets, where "economy of plenty" will assure, as we are told, that no one will have to work *much* for a living, and where the higher philosophy that holds "human rights above property rights"

(without perhaps clearly understanding what it means by either) assures that in any event everybody shall be kept alive at public expense whether he works or not, is there not the barest possibility that there might appear a somewhat general inclination on the part of the more intelligent members of the group to opt for the philosophy rather than for the communal work (however slight in amount)? If anything like this should happen might not the economy of plenty some day find itself once again in a parlous state of unplenty? Not being myself a dependable prophet I venture no answer. But in any case, and regardless of details, it is difficult to convince a biologist that a social philosophy will endure for any great length of time that deliberately and complacently loads upon the always weary backs of the able and fit an evergrowing burden. If there is one thing certain in the science of biology it is that no species or variety of plant or animal has long survived that was intrinsically incapable of making its own living. There is *somewhere* a biological limit to altruism, even for man. A large part of the world today gives the impression that it is determined to find the exact *locus* of that limit as speedily as possible.

IV

Up to this point the discussion has been of the social consequences of firmly established biological principles. In what regions of biology may there be expected with some confidence developments new in principle, and with important implications for human behavior, thought, and social relations? Probably not, one is fairly safe in saying, in such fields as morphology, embryology, or taxonomy. The advances in the field of genetics, which has to a considerable degree dominated biological thought during nearly a half century and will probably continue to for some time yet, will inevitably have an increasing influence on human affairs as the meaning of its advances is better understood. But this influence seems on the whole likely to be more of a negative than positive character—a matter of avoidances, taboos, and prohibitions rather than of positive contributions to human biological progress. Heredity represents the entailed side of biology—things given—about which it is extremely difficult really to *do* anything effective in the face of other compelling elements of human life and living, especially those elements belonging in the psychobiological realm.

It seems probable that advances likely to be made in physiology and psychobiology may profoundly alter human affairs and outlooks

in the not very distant future, and particularly in the direction of the greater release and more effective control of the energies and potentialities of man (and of other living things at will). In recent years the investigations and deductions of the psychiatrists, endocrinologists, and psychobiologists have thrown a beginning glimmer of real light upon the underlying biological bases of the activities and conduct of living things, and especially of man. We are beginning to understand in some detail and particularity how, conduct, normal and abnormal, moral and immoral, is the expression of "animal drives" or urges—themselves resultants of subtle chemical and physiological changes in the body—rather than of either free will or terrestrial and heavenly precepts. It does not seem extravagant to expect that as this understanding broadens and deepens ways may be found to bring it about that men will act somewhat more intelligently and less harmfully in politics, business, society, religion, and elsewhere generally, than they sometimes have in the past. The ever widening and deepening flow of biological knowledge is plainly furnishing a solid, scientific groundwork for a philosophy of life based on releases, in contradistinction to the philosophy of life based upon inhibitions and prohibitions that has so long held us enthralled. I am not unaware that current political philosophies in various parts of the world look backward in this regard, and insist on more prohibitions and regimentations. But they are going against biology, and if I read the history of evolution aright, biology will win. Nature is never in a hurry. And that odd bird the Blue Eagle was much shorter lived than even the poorest dinosaur.

This current trend of biology of which we have just been speaking has many different aspects. There are some who will recall the widespread interest and discussion stirred up many years ago by an essay of the late William James entitled *The energies of men*. It dealt with the release of normally untapped and unsuspected potentialities of men under certain conditions, sometimes those of shock and stress, sometimes under the impulsion of the will. Examples were given of men who, though enfeebled by poor health, performed feats of strength and endurance that would tax the finest athlete, when they encountered conditions that imperatively demanded such a performance.

We are working in the laboratory on another angle of the same general problem. We have experimented with seedlings, grown under very exactly controlled conditions such that all the matter and energy for growth and living (save for water and oxygen) come from the nutri-

tive materials stored in the cotyledons of the seed planted, which themselves are an integral part of the plant. Under these experimental conditions the seedling goes through a complete life cycle of germination, growth, adulthood, senescence, and eventual death. This life cycle corresponds quantitatively very closely to the normal life cycle of the plant in the field, except that it is greatly compressed and fore-shortened in time. By appropriate aseptic surgical procedures we have removed carefully measured parts of the food resources stored in the cotyledons of the cantaloup seeds we have used, and then observed the relative performance of such mutilated seedlings as compared with the normal controls, in respect of growth and duration of life. The net result is to demonstrate that the mutilated plants grow much larger and live many times longer, as compared with the normal controls, than they would be expected to in proportion to the amount of matter and energy for living available to them after the operation. The results indicated clearly that the operated seedlings utilized their available food resources much more effectively than the normal plant does. It is as though an inhibitor had been removed from the plant, freeing its potentialities for more adequate expression.

The possibilities suggested by these experiments seem far-reaching, though admittedly the exploration of the field has only just begun. Work in this direction on plants and lower animals may result in such an understanding of the physiology of releasing normally inhibited biological potentialities as to enable man to unleash effectively and usefully more of his own energies.

In the field of human biology the admitted and crying need is for adequate synthesis of existing knowledge. It is an obvious truism that we know more in detail about the biology of man than about that of any other organism. Anatomists, physiologists, anthropologists, psychologists, sociologists, and economists, have by analytical methods piled up a body of detailed information about man that is literally colossal. But what does it *mean* for humanity? Every thoughtful person will admit that there is a kind of moral necessity to go forward in the attempt to get a better and more comprehensive understanding of the whole nature of man. The material, mechanized civilization he has evolved may easily become a monster to destroy him unless he learns better to comprehend, develop, and control his biological nature. If inventions and discoveries cannot be intelligently managed after they are made, they are likely to be a curse rather than a blessing.

The bulk of scientific effort is, and always has been, directed to-

wards analysis unaccompanied by synthesis. Scientific men have mainly left it to philosophers and literary men to be the synthesizers of their data, shirking the task themselves with a few notable exceptions, of whom perhaps the greatest was a biologist, Charles Darwin. But analysis at best leads only to knowledge; while synthesis may furnish wisdom. And mankind sorely needs more wisdom right here and now!

PHARMACOLOGY.—*The toxicity for sheep of water solutions of hydrocyanic acid and the effectiveness of the nitrite-thiosulphate combination as a remedy.*[1] JAMES F. COUCH, A. B. CLAWSON and H. BUNYEA, Bureau of Animal Industry.

The results of a considerable number of experiments in which solutions of potassium cyanide were administered to sheep have previously been reported.[2,3,4] The potassium cyanide was administered as a drench and the quantity given in each base recorded as milligrams per kilogram of animal weight. In these experiments information was obtained concerning the smallest quantity of potassium cyanide that will produce symptoms in sheep, the smallest quantity that will kill and also concerning the effectiveness of a combination of sodium nitrite and sodium thiosulphate as a remedy for animals poisoned by potassium cyanide.

In the present paper data are presented concerning the toxicity for sheep of hydrocyanic acid in water solution and the remedial effectiveness of the nitrite-thiosulphate combination.

The solution of hydrocyanic acid used was prepared by mixing cold solutions of the calculated quantities of potassium cyanide and of tartaric acid in water and filtering off the precipitated potassium acid tartrate which was washed with a little cold water. The filtrate and washings were combined and diluted to a definite volume. The cyanide content of the solution was then determined by titration with N/10 silver nitrate solution and the strength was adjusted so that one cubic centimeter of solution contained 15.5 mg. of hydrocyanic acid. The solution contained less than 0.05 per cent of dissolved potassium acid tartrate which, in the doses given, was negligible.

A fresh solution was made each morning before experimental work, although analysis showed that there was no appreciable change in the strength of the solution when preserved for 72 hours in a cold place.

[1] Received February 28, 1935.
[2] This JOURNAL **24**: 369–395. 1934.
[3] This JOURNAL **24**: 528–532. 1934.
[4] This JOURNAL **25**: 57–59. 1935.